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The role of risk avoidance and locus of control in workers' near miss experiences: Implications for improving safety management systems

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ABSTRACT

The process industry has made major advancements and is a leader in near-miss safety management, with several validated models and databases to track close call reports. However, organizational efforts to develop safe work procedures and rules do not guarantee that employees will behaviorally comply with them. Assuming that at some point, every safety management system will need to be examined and realigned to help prevent incidents on the job, it is important to understand how personality traits can impact workers' risk-based decisions. Such work has been done in the mining industry due to its characteristically high risks and the results can be gleaned to help the process industry realign goals and values with their workforce. In the current study, researchers cross-sectionally surveyed 1,334 miners from 20 mine sites across the United States, varying in size and commodity. The survey sought to understand how mineworkers' risk avoidance could impact their near miss incidents on the job – a common precursor to lost-time incidents. Multiple regressions showed that as a miner's level of risk avoidance increased by 1 unit in the 6-point response scale, the probability of experiencing a near miss significantly decreased by 30% when adjusting for relevant control variables. Additionally, a significant interaction between risk avoidance and locus of control suggested that the effect of risk avoidance on near misses is enhanced as a miner's locus of control increases. A one-unit increase in locus of control appends the base effect of risk avoidance on near misses with an additional 8% decrease in the probability. Findings are discussed from a near-miss safety management system perspective in terms of methods to foster both risk avoidance and locus of control in an effort to reduce the probability of near misses and lost time at the organizational level within the process industry and other high-hazard industries.

1. Introduction

Regardless of industry sector, high-hazard work environments present unique risks in safety management. Because there is always the possibility of a hazardous incident (e.g., toxic chemical spill and release, explosion, fire), safety within the process industry can always be improved (Shamim et al., 2018). To better prepare workers to identify and appropriately respond to site-specific hazards, organizations often develop safe work procedures – in the form of safety, risk, or process management programs – to outline how and in what ways employees can keep themselves and their coworkers safe (Argote and Ingram, 2000; Hemingway and Smith, 1999; Katz-Navon et al., 2005; Makin and Winder, 2008; Wachter and Yorio, 2013; Zacharatos et al., 2005). The process industry is particularly advanced in these areas of safety management, near-miss management, and incident reporting in an effort to help prevent future incidents (for case study examples see Bragatto et al., 2010; Jones et al., 1999; Nivolianitou et al., 2006; Olewski et al., 2016). Most of these systems rightly and accurately focus on organizational implementation of such practices. Additionally, however, when organizations consider what constitutes a 'risk,' and if certain risks may lead to a near miss incident as aforementioned case studies have shown, it is also important to consider such risks through the lens of the individual worker to ensure better execution of any safety management system.

Several theories have attempted to understand how individual workers collectively view 'risk' and 'risky' behavior (i.e., Cree and Kelloway, 1997; Harrell, 1990; Huang et al., 2007; Sitkin and Pablo, 1992; Sitkin and Weingart, 1995). Decision-making frameworks suggest that the concept of risk is subjective and, therefore, it allows for different, intrinsically held perspectives regarding safe and unsafe

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behavior (Fischhoff et al., 1981). Additionally, motivation theories assert that there is a strong, fundamental need for personal safety in any context (Maslow, 1943; Steers et al., 2004). Together, these frameworks suggest that when workers make choices, they may not always view their actions as 'risky,' per se. However, research has shown that individuals' perceptions of risk significantly influence their risky behaviors and the subsequent probability of safety outcomes (Ba et al., 2016; Koornstra, 2009) making this topic important in the organizational, process safety literature.

Within the U.S. mining industry, regulatory oversight requires near miss reporting. This oversight closely aligns with high-risk process industries, which also require near miss reporting. These requirements for both industry sectors have provided information about hazard trends and mitigation responses. However, the role of individual factors in experiencing near miss incidents has not been studied specifically nor thoroughly (National Safety Council [NSC], 2013). Because studies have found causation with near misses and eventual incidents in a variety of industries (Knowles et al., 2009), there is value in determining how individual differences can impact safety choices. Such information would better inform safety management systems and subsequent interventions with workers. To that end, the purpose of this study was to understand if levels of risk avoidance, particularly when interacted with individual sense of control, impacts near miss experiences that occur among the workforce. This study examined the roles of these two traits in the frequency of near misses experienced by 1,334 mineworkers from 20 mines. Results showed that as a worker's level of risk avoidance and sense of control increased, the probability of the worker experiencing a near miss significantly decreased while adjusting for relevant control variables. These findings are discussed in relation to organizational-level interventions that can foster both risk avoidance and locus of control to reduce the probability of near miss occurrences and eventual incidents in the process industry.

2. Literature review

Any high-risk occupational sector requires safe working procedures to prevent accidents, making the management of risks a multilevel concern (Nordlöf et al., 2015). Because of the risks present at the organizational level most companies adhere to some type of safety management system that includes regular safety audits and analyses of work procedures and processes to help prevent and manage ongoing risks (ANSI Z-10, 2012; BS OHSAS, 18001, 2007). Within other industries, the Occupational Safety and Health Administration (OSHA) may issue other safety management guidelines or process safety management guidelines. Within OSHA's (2015a) updated process safety standard (29 CFR 1910.119) they require near miss reporting, specifically, as a component. This standard applies to "process operations" and states that employers must investigate each incident that resulted in or could reasonably have resulted in a release of catastrophic hazards into the workplace. For this reason, near miss management systems have drastically improved in process industries (Jones et al., 1999). Along these same lines and in the context of the mining industry, the Mine Safety and Health Administration (MSHA) requires that all serious near misses be reported quarterly. These include, for example, roof and rib falls, unexpected explosions, and failures of hoisting equipment. Thus, near misses represent a critical metric and learning component to any safety management system. Additionally, because the mining industry and process industry both organize their safety management systems around similar activities within the plan-do-check-act model (Bragatto et al., 2010; Mitchison and Porter, 1998; National Mining Assocation, 2014; OHSAS, 18001) it is believed that results and recommendations within one industry can be adopted by the other.

2.1. Defining near miss incidents

Due to the changing nature of industrial work environments it is likely that numerous near misses or close calls occur each workday. According to the NSC (2013) a *near miss* is an "unplanned event that did not result in injury, illness, or damage – but had the potential to do so" (np). Similarly, OSHA (2015b) discusses a near miss as an incident that could have caused a serious injury or incident but did not. Research has long argued that small-scale near misses have the potential to cause more serious events in the future (Heinrich, 1931) while recent research continues to show a statistical case that near misses often precede loss-producing incidents (Yorio and Moore, 2017). In this sense, near misses can be considered and treated as a leading indicator in safety performance (Janicak and Ferguson, 2009; Manuele, 2013). Specifically, effective learning from near misses can improve safety within the organization and enhance organizational productivity – all without experiencing an actual incident (Jones et al., 1999; Lukic et al., 2012). Alternatively, a lack of such processing and learning suggests that subsequent near misses are more likely to turn into injury and cost-producing incidents (Hewitt and Chreim, 2015). Unfortunately, learning to identify a near miss and subsequently encouraging the reporting of near misses and investigating them is still considered an "evolution" of risk management (Kuhn and Youngberg, 2002).

Therefore, recognizing the fundamental cause of a near miss, learning what went wrong, and responding to a near miss is a critical task of both workers and the organization – hence a large piece of the safety culture and risk management on site (Paté-Cornell, 2012, 2009). Corporate management must demonstrate a commitment to safety through its risk management process, which includes support to notice and identify a near miss followed by swift corrective actions to avoid future risks (Zou, 2011). This support, trickled down, helps situate near miss events as a critical component of a successful management system (Morrison et al., 2011). However, a gap in being able to tailor such management systems is that the impact of workers' individual factors and their safety performance, including the likelihood of experiencing a near miss incident, has not been studied (Judge et al., 2003).

2.2. Considering the roles of the individual in near miss experiences

Although process safety literature supports the need to analyze near misses to improve safety, another layer of this analysis is the consideration of workers' individual factors when assessing the likelihood of such occurrences. For example, research has demonstrated that if near misses are not adequately discussed, it can lead to riskier behavior due to lower perceived risk, or believing that the original perceived risk was over-estimated (Tinsley et al., 2012). In response, organizations must tailor some part of their safety management system to provide workers with resources to avoid personal risks and empower them with the decision-making autonomy necessary to carry out protective actions on the job. Within this manuscript, we examine two worker-level traits that are necessary to complement safety management to help prevent incidents: risk avoidance and locus of control. These traits are further discussed below.

2.2.1. Individual risk avoidance as it relates to near miss occurrences

Risk tolerance/avoidance/propensity (which we will discuss as risk avoidance hereafter) is an individual's tendency to take or avoid risks (Sitkin and Weingart, 1995). Numerous risk, decision making, and behavioral models and processes suggest that individuals make risk-based decisions grounded in their individualized concept of risk (Eklöf and Törner, 2002; Harrell, 1990; Huang et al., 2007; Mearns et al., 2001; Sitkin and Pablo, 1992; Slovic et al., 2005; Rundmo, 2001; Van der Pligt, 1996). Therefore, one advantage *or* disadvantage, depending on the individual, is that risk avoidance is an emergent trait that can change (Sitkin and Weingart, 1995). Numerous situations combine and interact over time to define the way that risk is holistically evaluated for each individual (Reason, 1997). A near miss is just one occurrence that has the potential to change someone's trait characteristics and willingness to take risks (Dillon and Tinsley, 2008).

Dillon and Tinsley (2008) argue that saliency of risk information must be embedded in a near miss discussion in order to maintain a high level of risk avoidance in the future. Consistently highlighted precursors (e.g., Eklöf and Törner, 2002; Harrell, 1990; Huang et al., 2007; Mearns et al., 2001; Sitkin and Pablo, 1992; Rundmo, 2001) that can be discussed to maintain risk saliency include workers' habits and routines and their ability to deal with or respond to risks over time; workers' outcome history such as success or failure with prior strategies to deal with risks; workers' risk biases and the degree of risk that is tolerable; workers' social influences and available information to a given risk; and workers' contextual prompts such as rules that communicate about relevant risks. Although risk avoidance has been studied as an emerging trait that may be influenced by a near miss, this individual characteristic has not been studied as a predictor of near misses occurring in the first place, serving as an impetus within this study.

2.2.2. Individual locus of control as it relates to near miss occurrences

In addition to risk avoidance, personal locus of control is an internal, emergent trait that can influence decisions on the job but has not been explicitly studied in relation to near miss experiences. Rotter (1966) defines locus of control as an individual's belief about the causes of the events, circumstances, and outcomes in his or her own life and whether individuals see these outcomes as being contingent on their own behavior. In other words, this personality trait represents the extent to which people believe that the rewards they receive in life are based on their own actions (Lefcourt, 1976). Previous research has shown that individuals who have a higher locus of control can more objectively deal with situations that occur on the job, have a better perception of their work environment, and are more motivated on the job (Erez and Judge, 2001; Judge et al., 1998). Additionally, locus of control has been found to influence workers' social skills, including their ability to adequately respond to stressful or potentially risky situations (e.g., a near miss) (Lefcourt et al., 1985; Ringer and Boss, 2000). More specifically, workers with a higher locus of control have demonstrated more proactive qualities and tend to engage in problem-focused activities such as reducing a hazard (Gianakos, 2002; Ng and Butts, 2009; Ng et al., 2006).

Organizational characteristics that have been found to influence workplace incidents include hazardous working conditions (Leigh, 1986); managers' support for health and safety (Koster et al., 2011; Sadiq and Graham, 2016); job demands (Ng and Butts, 2009; Ng et al., 2006), and general involvement in decision making (Galizzi and Tempesti, 2015). However, personal characteristics of the individual have yet to be applied in the same way to reveal causes in workplace incidents (Crant, 2000). Due to these unknowns, it is preferable to study how workers' perceived, personal characteristics – such as risk avoidance and sense of control – may influence incidents directly (Weyman and Clarke, 2003).

2.3. Research objectives

This study analyzed the relationship between the occurrence of near miss incidents and workers' perceived measures of risk avoidance and personal locus of control. Focusing on the interaction of two individual traits on an outcome, specifically for locus of control (Ng and Butts, 2009), is less common in applied research. Because research has suggested that individual factors should be studied as a predictor of near misses (NSC, 2013) in an effort to learn more about their impact on worker decision making (e.g., Spreitzer, 1995; Vardi, 2000) this study was deemed warranted. Related to the process industry, although near miss reporting is an important aspect of mandated safety management programs (e.g., 29 CFR 1910.119 in the U.S.) it is rarely studied as a dependent variable in empirical studies.

2.3.1. Hypotheses

H1. Mineworkers' risk avoidance will reduce the likelihood of experiencing a near miss.

H2. Mineworkers' sense of locus of control will moderate the effect of risk avoidance on near misses.

3. Materials and methods

A safety climate survey was developed for the mining industry by the National Institute for Occupational Safety and Health (NIOSH). Through an extensive literature review of safety climate assessments in other high-risk occupational industries, several worker perception-based organizational value and characteristic constructs were identified and presumed to be important in fostering safety knowledge, motivation, behaviors, and outcomes. As a part of the safety climate assessment completed by participants, risk avoidance was one factor, or scale, contained within the survey as well as personal sense of control. This paper focuses specifically on the risk avoidance and personal sense of control measures, and their potential influence on near misses.

3.1. Survey instrument

3.1.1. Risk avoidance scale

Measuring risk avoidance can help predict the types of at-risk behaviors in which workers are willing to participate (Hatfield and Fernandes, 2009). Thus, a risk avoidance scale was adapted and used to measure an individual's general tendency to take and avoid risks on site. A scale was adapted from Meertens and Lion (2008) risk propensity scale. Their original scale contained nine items to tap into difference aspects of risk-taking and yielded a Cronbach's $\alpha = .80$. In the current survey, the scale was adapted to a four-item measure which workers were asked to complete using a six-point Likert scale (strongly disagree to strongly agree) with six being the highest value, indicating a high avoidance of risks. The four questions were prefaced with "As far as day to day work …" and were phrased as follows:

- I do not take risks with my safety/health.
- I take risks regularly (reverse-scored item).
- Safety comes first.
- I prefer to avoid risks.

Within the current sample these questions rendered a Cronbach's $\alpha = 0.72$, which is an acceptable level of internal consistency (Nunnally, 1978; Cronbach, 1951).

3.1.2. Personal locus of control scale

The locus of control construct was adapted from previous constructs that measured core self-evaluations (Judge et al., 2003; Parker et al., 2006). These scales, containing anywhere from four to 12 items, have demonstrated varying levels of reliability (Cronbach's $\alpha = 0.57$ to 0.75). We adapted these previously validated scales, using four of the items, which rendered a Cronbach's $\alpha = 0.70$. This is an acceptable level of internal consistency, and also similar to what previous studies have produced, including Gardner and Pierce (2010) locus of control scale (Cronbach's $\alpha = 0.66$). Therefore, the researchers were comfortable with the internal consistency of the following four-item scale:

- I can pretty much accomplish whatever I set out to accomplish.
- If I were unhappy with a decision made by supervisor, I could do something about it.
- If I take the right actions, I can stay healthy and safety on the job.
- Most of the problems that I experience are 'out of my hands' (reverse-scored item).

3.1.3. Near miss documentation

Additionally, mineworkers who participated were asked to report their frequency of near misses experienced on site in the last six months.

Regarding accuracy, six months is the recommended, maximum time over which workers should be asked to recall incidents or injuries (Veazie et al., 1994; Zacharatos et al., 2005). Everyone was prompted to check one of the following: Never, Once, 2 times, 3 times, 4 times, or 5 + times.

3.2. Recruitment and data collection

After human subjects approval was received, data collection occurred between April 2015 and April 2017. Individual mines were initially recruited through research contacts. Once initial data collection with the first company was completed and pilot results were communicated during various mining trade and conference presentations, subsequent participating sites contacted NIOSH to participate. Upon being contacted by a corporate H&S leader, mine operator, or H&S manager, a mutually agreed-upon time was chosen to travel to the mine and administer the survey. If an upcoming MSHA annual refresher training (ART) was scheduled, researchers often visited the mine that day in order to have everyone together at one time. If an upcoming training was not on the mine's schedule in the near future, researchers worked with the mine to pick one or two days that were convenient to attend pre-shift safety meetings to collect the survey data. In this scenario, researchers would often be present at the mine location all day to catch varying shift rotations.

Prior to participating, mine management and hourly workers were briefed about the purpose of the survey, that their responses would be anonymous, and that their answers would not be seen by their supervisors. Everyone was given the option to voluntarily participate and given contact information of the principal investigator if they had any questions. To our knowledge, no one refused to participate and it took approximately 15 min to complete the survey. Researchers collected the hard copy surveys and subsequently they were entered into a statistical data file for cleaning and analysis.

3.3. Participants

Participants consisted of 1,334 hourly and salary mineworkers from 20 mines in 10 states throughout the United States. The mines represented six major companies and three mined commodities. The breakdown of participation by commodity was stone, sand, and gravel ($n = 630$, 47%); industrial minerals ($n = 424$, 32%); and coal ($n = 280$, 21%). The range of participants at each mine was 22–280 (M = 67). Of the sample, $n = 63$, 5% were 18–24 years old; $n = 264$, 21% were 25–34 years old; $n = 319$, 25% were 35–44 years old; $n = 347$, 27% were 45–54 years old; $n = 258$, 20% were 55–64 years old; and $n = 35$, 2% were older than 65.

Additionally, 22% of the participants were salary workers and 78% were hourly. Participants were asked about time in their current job, time at the current mine, and time in the mining industry. For time in the mining industry, 10% had under 1 year of experience; 21% 1–5 years; 19% 6–10 years; 19% 11–15 years; 9% 16–20 years; and 23% over 20 years. Over half of the sample ($n = 659$, 52%) were in production and on a rotating shift. A majority of the sample either had a high school degree ($n = 752$, 58%) or an associate's/trade degree ($n = 350$, 27%). The rest either had a bachelor's or master's degree or less than a high school education. Finally, 93% of the sample were male and 7% were female.

3.4. Near miss distribution

Regarding the distribution of near miss incidents experienced by participants, the average was 0.83 with a SD of 1.23, based on their recall over the last six months. Among the sample, over half indicated that they did not experience a near miss ($n = 747$, 57%), followed by once in the last six months ($n = 282$, 22%); two times ($n = 126$, 10%); three times ($n = 80$, 6%); four times ($n = 39$, 3%); and finally five or more times ($n = 30$, 2%). Although over half of the sample was zero, the model was not subject to a zero-inflated model with the mean being 0.83. Rather, zero-inflated models should be considered when the mean is < 0.07 or < 0.05 (Lord, Washington, & Ivan, 2005).

These incident outcomes could be cross-checked with the participating mine sites due to their own reporting and auditing of incidents. Specifically, the near miss occurrences were checked against several of the mines' internal databases via the manager or operator. In several instances the near misses were identical or within an extremely close range, indicating an understanding and accurate recollection of near misses or incidents experienced in the last six months.

3.5. Analysis

To account for the potential dependence among individuals nested within organizations, a Generalized Estimating Equations (GEE) approach was used (Hardin and Hilbe, 2003). Given that the outcome (near misses) is a count variable, non-normally distributed Poisson and negative binomial models were examined and compared using fit indexes within a GEE framework. The negative binomial model displayed more desirable Quasi and Corrected Quasi Likelihood fit statistics. Thus a negative binomial distribution was assumed within a GEE model framework.

Personal-based control variables of age, mining tenure, education, gender, and job classification were included. Age and mining tenure were entered as continuous covariates. Education, gender, and job classification were entered as factors. The final models took the form of:

$$\begin{aligned} Log(P[Near\ Misses]) = {} & B_0 + B_1(Age) + B_2(Mining\ Tenure) \\ & + B_3(Education)_i + B_4(Gender) \\ & + B_5(Job\ Classification) + B_6(Risk\ Avoidance) \end{aligned} \quad (1)$$

$$\begin{aligned} Log(P[Near\ Misses]) = {} & B_0 + B_1(Age) + B_2(Mining\ Tenure) \\ & + B_3(Education)_i + B_4(Gender) \\ & + B_5(Job\ Classification) + B_6(Risk\ Avoidance) \\ & + B_7(Locus\ of\ Control) \\ & + B_8(Risk\ Avoidance * Locus\ of\ Control) \end{aligned} \quad (2)$$

Equation (1) was executed to examine H1 and equation (2) was executed to examine H2. The interpretation of the exponentiated regression coefficient (the incident risk ratio, IRR) for B_6 is the increase/decrease in probability of a near miss for each unit increase in a miner's risk avoidance. A similar interpretation is appropriate for B_6 and B_7 in equation (2). The interaction term, B_8, represents the multiplicative effect between risk avoidance and locus of B_6 control and the additional increase/decrease in the IRR for risk avoidance that can be expected for each unit increase in locus of control. Prior to the examination of equation (2), both risk avoidance and locus of control were appropriately centered by subtracting the grand mean from each individual value.

4. Results

Table 1 shows the mean, standard deviation, and correlations among the continuous variables in the model. Age and mining tenure were entered as continuous covariates.

4.1. Hypothesis 1

Table 2 reports the results for equation (1). These results support hypothesis 1 in that a one-unit increase in a miner's risk avoidance is associated with a 34% decrease in near miss probability.

The only control variable to significantly influence the likelihood of experiencing a near miss was education. In terms of education, the

Table 1
Means, standard deviations, and correlations among the continuous variables in the model.

Variable	Mean	SD	1	2	3	4
1) Near Misses	0.85	1.28	–			
2) Age	39.05	10.09	0.05	–		
3) Mining Tenure	8.28	7.32	0.06*	0.54**	–	
4) Risk Avoidance	5.29	0.77	−0.23**	0.06*	−0.02	–
5) Locus of Control	4.95	0.80	−0.14**	−0.04	−0.11**	0.37**

Note: *p < .05, **p < .001.

results shown in Table 2 suggest that workers with an education level below the high school level are relatively at greater risk of experiencing a near miss when compared to miners with bachelor's and master's degrees ($p < .05$) and workers with a trade certificate and high school diploma ($p = .07$). Follow-up mean pairwise comparisons of near miss counts among the groups of miners delineated by education level suggest that workers with an education level below the high school level ($M = 1.04$) significantly differ from workers with a high school education ($M = 0.73$, $p = .046$), those with a trade certification ($M = 0.67$, $p = .037$), those with a bachelor's degree ($M = 0.42$, $p = .019$), and those with a master's degree ($M = 0.54$, $p = .014$).

4.2. Hypothesis 2

Table 3 reports the results of equation (2). These results support hypothesis 2, showing that the effect of risk avoidance on near misses remains significant ($IRR = 0.66$, $p < .001$) with the inclusion of locus of control and the interaction term between them. There was a significant 14% decrease in the near miss probability for each unit increase in a workers's locus of control. There was also a significant interaction between risk avoidance and locus of control ($IRR = 0.92$, $p < .001$).

Similar to the results in Table 2, education was the only control variable to exhibit a significant effect on near misses. The pattern of relative risk and follow-up pairwise comparisons on near miss mean counts by miner group delineated by education was also consistent with those reported from Table 2 and equation (1).

5. Discussion

Safety management systems contain elements that address organizational change, which includes near miss management (ANSI/AIHA Z10-2005, BS OHSAS, 19001:2007). Although safety management systems and databases for reporting accidents and incidents in the process industry has made major advancements (Nivolianitou et al., 2006), others have argued that some industries, such as the chemical industry as a whole, does not learn from accidents (Chung and Jefferson, 1998). Such research has argued that better dissemination of information is needed. However, the current results also demonstrate that workers' individual factors need to be considered and addressed when considering how to disseminate aspects of safety management. Specifically, our results show that, not only do workers' risk avoidance traits impact their decision making, but also that personal locus of control has significant interaction effects that can influence workers' eventual safety outcomes. Therefore, if one's locus of control is higher, he or she is more likely to avoid risks and vice versa. What is important about these results as they relate to the gap in current research is that these individual characteristics can still be influenced by organizational characteristics such as decision making authority bestowed onto an individual, opportunities provided to use knowledge and skills, and the option and ability to participate in discussions (Karasek and Theorell, 1990). In other words, a root cause, and perhaps a potential solution, of organizational conflicts regarding workplace safety may reside in understanding the processes undertaken by organizations to communicate with individuals in developing their risk evaluation criteria (i.e., what constitutes safe and risky behavior in the workplace). Through this greater understanding, safety practitioners can theorize and glean more effective methods to facilitate alignment between management and hourly workers. We argue for pragmatic enhancements to any organizational safety management system to enhance workers' individual characteristics toward risk and control on the job.

5.1. Implications for tailoring safety management systems

The concept and need to manage change within a safety management system is not new within the process industry. Specifically, the Center for Chemical Process Safety (CCPS) asserted that near misses and subsequent incidents are often attributed to inadequate management and alignment within safety management systems (2008). Additionally, Macrae (2016) stated that the mistranslation of near miss identification and reporting from a variety of industries has left employees with “confused and contradictory approaches to reporting and learning, seriously limiting the impact of potentially powerful safety improvement strategies” (p. 71). Further, research has shown that a negative relationship between safety communication and occupational near misses/accidents exists (e.g., Morgeson and Hofmann, 1999; Mearns et al., 2003). Despite research that supports such communication,

Table 2
Near misses regressed on risk avoidance and control variables in negative binomial GEE framework.

Variable	B	Std. Error	Wald Chi-Square	P value	Exp(B)- IRR	95% CI for Exp.(B)
Job Classification			3.30	0.19		
Salary	0.36	0.35	1.08	0.30	1.43	0.73, 2.82
Hourly	0.29	0.19	2.38	0.12	1.36	0.93, 1.93
Contractor	–	–	–	–	–	–
Education			18.92	0.001		
Master's	−0.65	0.28	5.27	0.02	0.52	0.30, 0.91
Bachelor's	−0.91	0.24	14.06	< .001	0.40	0.25, 0.65
Trade Cert	−0.43	0.24	3.28	0.07	0.65	0.41, 1.04
High School	−0.35	0.19	3.30	0.07	0.70	0.48, 1.03
< High School	–	–	–	–	–	–
Gender			0.87	0.35		
Male	0.14	0.14	0.87	0.35	1.15	0.86, 1.53
Female	–	–	–	–	–	–
Age	0.03	0.06	0.21	0.65	1.03	0.92, 1.14
Mining Experience	0.03	0.05	0.45	0.50	1.03	0.94, 1.53
Risk Avoidance	−0.42	0.05	64.14	< .001	0.66	0.59, 0.73

Note: For the categorical control variables Job Class, Education, and Gender, the last factor category is the reference group: Contractor is the reference for the relative risk reported for Salary and Hourly workers; < High School education level is the reference for the relative risk reported for the remaining education categories; and Female is the reference for the relative risk for Males.

Table 3
Near misses regressed on risk avoidance, locus of control, and their interaction along with control variables in negative binomial GEE framework.

Variable	B	Std. Error	Wald Chi-Square	P value	Exp(B)- IRR	95% CI for Exp.(B)
Job Classification			2.43	0.30		
Salary	0.38	0.35	1.16	0.28	1.46	0.73, 2.90
Hourly	0.28	0.19	2.10	0.14	1.32	0.91, 1.93
Contractor	–	–	–	–	–	–
Education			19.20	0.001		
Masters	−0.71	0.29	5.79	0.02	0.52	0.27, 0.88
Bachelor	−0.96	0.25	14.17	< .001	0.40	0.23, 0.63
Trade Cert	−0.49	0.26	3.52	0.06	0.65	0.37, 1.02
High School	−0.40	0.22	3.37	0.07	0.70	0.44, 1.03
< High School	–	–	–	–	–	–
Gender			0.58	0.44		
Male	0.11	0.15	0.58	0.44	1.12	0.84, 1.50
Female	–	–	–	–	–	–
Age	0.03	0.06	0.28	0.59	1.03	0.92, 1.15
Mining Experience	0.03	0.05	0.33	0.57	1.03	0.94, 1.12
Risk Avoidance	−0.42	0.05	61.73	< .001	0.66	0.60, 0.73
Locus of Control	−0.16	0.06	7.99	.005	0.86	0.77, 0.95
Risk Avoidance * Locus of Control	−0.08	0.02	14.60	< .001	0.92	0.88, 0.96

ongoing barriers, including discouragement from management to share near misses, using one-way channels of communication from the top down about near misses, along with avoiding engagement and worker learning to prevent future incidents, still exists.

The results of the current study show that ways in which near misses are discussed with the workforce can be improved, especially of workers are more tolerant of risks and have minimal perceptions of control on the job. Specifically, if workers experience a near miss in a high-risk situation but do not get hurt, they may build up a sense of resilience and tend to be more tolerant of such risks in the future and actually make riskier decisions. Some researchers term these experiences in which workers do not get hurt nor perceive a threat from a similar hazard in the future as a resilient near miss (Dee et al., 2013; Tinsley et al., 2012). To prevent workers in the process industry from making riskier decisions in the future, we argue that communication with workers around their vulnerability in these scenarios should be discussed. A vulnerable near miss can be fostered through a basic discussion of the potential incident, including the recognition of hazards, interpretation of potential consequences, and finally, that an incident did *almost happen* (Dillon et al., 2014). To encourage the interpretation and framing of a near miss as a vulnerable situation rather than a resilient situation, it is important to avoid framing the scenario to workers in a way that enhances internal risk biases (Dee et al., 2013), including comparative optimism, unrealistic optimism, or optimistic bias (Price et al., 2002; Zohar and Erev, 2007). Previous case studies in the offshore process industry has confirmed that focusing on near misses in a positive, knowledge-building way, can increase learning (Jones et al., 1999).

5.1.1. Active communication, involvement, and follow-up surrounding near miss occurrences

Agreed-upon advantages of using near miss incidents as an organizational tool to manage and improve individual worker safety are all centered around using the events as a communication impetus to discuss consequences of an incident, contributing factors to an incident, and safety factors in place on site (Heinrich, 1931; Heinrich et al., 1980). However, if the planned and deliberate communication around near misses fails to occur with the workforce then it will not take long for misalignment between employee-level and organization-level perspectives of risk to occur. Misalignment, or workers' perceived sense of little control on the job, can be fostered rather quickly if sharing errors and near misses on the job is not endorsed by management. Previous research has found that when near miss reporting is discouraged, negative safety outcomes are likely to increase (Cigularov et al., 2010). Enhanced safety communication about errors or near misses have been encouraged in construction safety management among other industries (Griffin and Neal, 2000; Mearns et al., 2003; Probst, 2004). According to previous research, encouraging this type of communication not only enhances safety awareness and recognition of a problem – which is one aspect of locus of control – but also increases reporting of such incidents (Clarke, 2003; Edmondson, 1996).

Although the process industry and complementing legislation around near miss reporting have acknowledged that if knowledge around near misses increase, reporting may go up (Bragatto et al., 2010), there still has not been guidance in how to cater to workers' individual risk traits around job-specific hazards. As discussed earlier, there are several aspects of a workers' risk tolerance that may influence a safe or risky decision (e.g., overestimating experience, familiarity with a task, severity of the outcome, and potential gain from risky actions) (Fennell, 2017). These factors can be used to initiate dialogue with the workforce. Also, fostering more informal learning in a spontaneous, natural setting may allow workers to talk more freely about the near miss or subsequent incident. Most of the time, information about a near miss is just disseminated to everyone but often fails to adequately involve the workforce in proactive learning to prevent incidents (Macrae, 2008; Sepeda, 2006). To better align the workforce with organizational management, it is important to engage all employees in some sort of a near miss management system that promotes the continuous identification and reporting of hazards.

Specifically, learning from near misses, rather than just being alerted, can only occur from social, participative processes that involve individuals and the organization reorganizing their shared knowledge and practices (Wenger, 1998). Engaging front-line workers is a necessity, given their ongoing position to identify hazards and potential problems, as well as the part they can have in enhancing organizational learning for other workers. Along these lines, management should foster a blame-free space that allows workers to question aspects of the organizational system – which has been shown to help workers develop their own solutions to hazards through a deeper level of learning (e.g., Lukic et al., 2012). In response, participating in active feedback with workers when a near miss is reported and debriefed with the entire site is critical to aligning the organization while increasing workers' sense of control on the job.

We argue that these communications can foster a greater sense of trust among the workforce which is critical to responding to near miss incidents. However, post-incident it is more common to assign blame, including "who didn't notice this" and "why was this ignored" (Paté-Cornell and Cox, 2014). Even worse, when this type of lagging information is the only data collected, many aspects of near miss identification and response remain a mystery (Wang, 2006). When blame and perceived lack of trust are fostered, employees have little motivation to report and discuss near miss incidents. Alternatively, research has argued that, through increasing personal and organizational control, performance risk (i.e. engaging in at-risk behaviors) will decrease (Das and Teng, 2001). In order to increase these aspects of control on the job, these authors argue that trust-building is critical, and often a missing piece in organizations. Although areas of miscommunication, lack of support and involvement, and trust can be difficult barriers to overcome, there are areas within an organizational safety management system that can be better emphasized, changed, or improved to help realign organizational and worker goals to enhance worker traits on the job. Specifically, we advocate that improving aspects of organization's safety management systems are an initial step in the alignment process with workers to enhance their sense of risk assessment and control.

6. Conclusions

Although this study took place in the mining industry, the implications can be applied within all high-hazard process industries. Both mining and the process industry require near miss reporting but have not specifically studied the individual worker aspects that may contribute to such occurrences and the subsequent prevention of incidents. Due to the dynamic nature of both work environments and the likelihood that both mineworkers and process workers face changing hazards daily, it is believe that safety management systems within both industries can learn from these results to communicate with their workforce.

To date, near miss reporting and management has primarily served to track the assurance of safety and inform safety management systems (ICAO, 2009). As a result, most research in industries ranging from process to aviation to construction advocates for collecting a large amount of systems-based information (Thoroman et al., 2018). However, to date these systems have not accounted for the characteristics of individuals within these systems and how their perceptions on the job may influence near miss management both in a proactive and reactive sense. The current study identified a linkage between workers' risk avoidance and sense of control and the occurrence of near misses on the job that can be explored among management in the process safety industries as well. Understanding workers' perceptions and how their individual characteristics can influence the likelihood of experiencing a near miss is critical to preventing future incidents. In other words, workers make up a large part of a resilient system (Hollnagel et al., 2007) and need to be addressed both when trying to prevent, identify, and respond to near miss incidents regardless of the industry-specific hazards present.

6.1. Limitations

The results of this study must be taken into account with its limitations. First, although the sample was large and no assumptions were violated during the analysis, this is only one sample among a variety of high-risk occupations. Additionally, due to the self-reported nature of the results, social bias is always a factor that needs to be acknowledged. Similarly, since organizations may define a near miss differently, these frequencies are also subjective in nature and may be different than what the actual organization has on file. Another key takeaway from a comparison of near miss management approaches within safety management systems indicated that an efficient design and use of system processes requires an in-depth analysis of the specific industry (Gnoni and Lettera, 2012). These limitations should be considered while interpreting the results. However, participants did not often have questions about what a near miss was while taking the survey, indicating a general understanding of the term. It is also quite possible that organizations have made changes to their near miss management systems but the changes have not yet been formalized and, therefore, the impact remains unclear at this time. Moving forward, it is hoped that companies start documenting aspects of their near miss management systems as a part of formal safety management system processes.

6.2. Directions for future research

As discussed, if aspects of safety management systems are not effectively designed and executed, relevant knowledge and consistent actions are often mismatched (Gnoni and Lettera, 2012). The results of this study show that individual factors have a significant impact on near miss occurrences on mine sites and perhaps the same holds true for the process industry. Therefore, the results are illustrated in a way that can be used within the sphere of organizational safety management for all high-hazard industries. Specifically, interventions that focus on enhancing intangible aspects of organizational management including communication, involvement, and trust with the workforce should be further explored not only within mining but all industries. It is important to note that improving processes within an organization's formal and informal risk management practices may not immediately be seen in terms of reduced incidents or near misses. However, this is only because these accident rates are low and near misses are not always reported (Mitropoulos et al., 2003). However, determining changes in worker attitudes (i.e. sense of control) and behaviors (i.e. risk avoidance/tolerance) can be readily observed in response to these changes in management.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jlp.2019.03.005.

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